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George Benjamin Goddard
University of Massachusetts Amherst

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by

George B. Goddard

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STATEMENT OF THE PROBLEM

One of the problems confronting a commercial greenhouse operator who is a grower of poinsettias is too early flowering, especially those plants which are propagated early. Plants which are propagated in June or July frequently come into full bloom in early December. This means that these plants are past their prime by Christmas. Growers who have followed general recommendations with regard to extending the length of day by artificial light to delay flowering have sometimes retarded the flowering of plants propagated in August to the extent that the plants were not in flower at all until after Christmas. Since the poinsettia is a seasonal crop, this late flowering means a considerable financial loss to the grower. Other growers have resorted to growing their crop at a temperature of 55^{o} F which will retard the flowering slightly; however, the incidence of disease at this temperature is very high and again serious losses have resulted.

This problem was undertaken in an effort to determine the answers to two major questions which are of importance to commercial poinsettia growers.

1. What is the optimum period to apply artificial illumination to poinsettia plants that have been propagated as cuttings in June, July and August in order for these plants to flower

the week before Christmas when they will be marketed?

2. Does the application of artificial light to delay flowering cause an undesirable stem elongation, thus producing a taller plant?

REVIEW OF LITERATURE

Until 1950, little work had been devoted to studying the photoperiodic responses of poinsettias. The first report that poinsettias were dependent on daylength to flower was made by Garner and Allard (7) in 1920. At this time they reported having subjected poinsettia plants to 10-hour days, 12-hour days, and normal days beginning in July. The plants receiving 10-hour days flowered in five to six weeks, while those receiving normal daylength did not flower until late November. In later and more detailed experiments these same men (1) began their treatments in May, and found that by carefully controlling daylength, they could control flowering of poinsettias. They discovered that the longer the days, the longer it took for the plants to flower and those which received 14½-hour days achieved heights of 91 inches, while those receiving only 10-hour days did not exceed 47 inches. As a result of these experiments, they classified the poinsettia as a short day plant which is "A plant in which flowering is initiated under a given, usually relatively short, day length and appropriate increase in the day length suppresses flowering or causes it to be delayed or less profuse" (1).

Post (14) in 1936 reported an experiment whereby he applied black shade cloth over poinsettia plants at 5 PM and removed it at 7 AM. This treatment began on July 15 and was repeated on additional plants every five days until it was discontinued on October 1. The following year he applied 4 hours of additional light beginning September 15 and repeated at 5-day intervals. The plants which were lighted, failed to flower; and the plants which were shaded soon began to show evidence of flower buds. From this work, he concluded that the normal flower bud-forming period for poinsettias is between October 10 and October 20 at Ithaca, New York (latitude 42° N).

In some preliminary work reported in 1938 by Roberts and Struckmeyer (20) it became obvious that temperature as well as day length played an important part in the flowering of poinsettias. Plants grown at a night temperature of 70° F produced abundant vegetative growth, but failed to flower; those grown at 63° F flowered normally while plants grown at 55° F failed to flower and also had only limited vegetative growth. Leaf and flower abscission occurred on plants which had been grown at 65° F when they were placed in a greenhouse and grown at 70° F. They concluded that temperature and photoperiod may interact in such a way that flowering of poinsettias does not occur even though the photoperiods are presumed adequately short.

Post (15) later discovered that the answer to this problem lay in the intensity of light that was received by the plants. Plants receiving high temperatures in the summer flowered under short day conditions while in the fall, they often did not. He discovered that a temperature higher than 65° F will not prevent flowering providing the light intensity is above 500 foot candles and the photoperiod is correct.

In more detailed experiments in which studies were made of both photoperiod and temperature Roberts and Struckmeyer (21) report that poinsettia plants failed to flower at temperatures of 70-75° F regardless of the daylength, at 63-65° F with long days, or at 55° F with short days. Plants did flower at temperatures of 63-65° with short days and "tended" to flower at 55° with long days. It should be pointed out at this point that Roberts and Struckmeyer were not aware of the work by Post (15) when they published their information.

Post (16) was the first to recognize the problem of late flowering and even more important, the application of certain principles to correct this problem. He recommends that flowering of poinsettias can be delayed by keeping the temperature over 65° at night beginning October 10 or by applying additional light on the same date and continuing the treatment for as many nights as the delay is desired. It is also pointed out that the latter treatment is preferred because the results are more uniform. Any varieties that normally flower a little late for Christmas can be advanced by applying black cloth shade to reduce the day length starting as many days in advance of October 10 as the grower desires to have the plants in bloom in advance of the normal season.

The most complete work on photoperiodic responses of poinsettias was published in 1950 by Parker, Borthwick, and Rappleye (13). Experiments had been carried on for four years under carefully controlled conditions. The work done in 1946 was a preliminary investigation to test the relative effects of photoperiods of 8, 10, 11, 12, 13, and 14 hours. The plants were all given 16 hour days from the latter part of August until October 11 when they were transferred to the shorter photoperiods. From this experiment they were able to observe that the plants receiving 8, 9, 10, and 11 hour photoperiods all flowered about the same time. Plants receiving 12 hours of daylight were retarded and had only a few small colored bracts when the plants receiving the shorter days flowered. The plants receiving 13 and 14 hours of light remained green and vegetative.

The following year experiments were designed to study the amount of radiant energy that was needed to effectively prevent floral initiation and development. An attempt was also made to study the effect of increasing the length of days after flower bud initiation had occurred. From the latter it was found that plants which were transferred to long days after initiating flower buds failed to form normal flowers. If the plants were transferred to long day conditions after the flower buds became visible, the buds abscissed leaving only a few bracts.

In order to determine the amount of radiation required to prevent flower bud initiation, various light intensities were applied to the plants each night from 1 AM to 2 AM. The intensities at the tops of the plants were controlled as accurately as possible and the amounts given the plants ranged from 0.5 foot candles in the darkest plot to 32 foot candles in the most brilliantly lighted plot. All of the plants failed to flower by mid-January when the experiment was discontinued and enabled them to report that 0.5 foot candles, corresponding to an energy of 30 foot candle minutes, was sufficient to prevent flower bud initiation.

During the third year, an experiment was designed to include such factors as the time of taking the cuttings, length of photoperiod, and the date of beginning the photoperiod. Six lots of cuttings were taken from July to mid-September. To avoid any lack of uniformity of daylength that the plants might be exposed to, all plants were subjected to 16 hours of light throughout the summer until the experiments were started. At varying times, plants were removed from the long day treatment and placed under 8, 9, 11, and 12 hour photoperiods. From this they observed that plants were in full bloom 65 to 75 days after the beginning of short days. Daylengths of 8 or 9 hours were about equally effective in causing flowering. Flowering was only slightly delayed with 11 hour days but was very much delayed with 12 hour days. Cuttings which were taken late did not respond immediately to short days.

Some plants were shifted from the 8 hour photoperiod to the 12 hour photoperiod on November 19 and December 3 to study the rate of flower development under these conditions. It was discovered that the rate did not differ at all from the control plants. Neither did the reverse transfer affect the rate of flowering significantly. The results suggest that 8 hour photoperiods were considerably more effective than 12 hour ones in getting floral initiation under way; however, once the process was started, the two photoperiods did not have markedly different affects on the rate of flower development. The only differences that they were able to observe in bract size was between the oldest and the youngest plants, the latter having the smaller size.

Post (18) realized that it is not the short days which cause flower bud initiation in poinsettias, but rather the long nights. By applying artificial light at various times during the night he was able to determine that poinsettias required a minimum dark period of at least $14\frac{3}{4}$ hours. Therefore, it became just as practical to apply lights for a shorter period of time in the middle of the night as it was to extend the length of day. This also served to substantiate the claims of Parker, Borthwick, and Rappleye (13).

Up to this point most of the work done on poinsettias was by lighting the plants continuously from at least August until early October, at which time plants were allowed to receive either normal daylengths or were given experimental daylengths. Carpenter (5) questioned the practicality of lighting for this long period and recommended that growers light for a shorter growing period. He subjected eight varieties of poinsettias to long days by applying artificial light from 5 to 8 PM daily from September 20 to October 1. These plants flowered on December 20 rather than December 10 for those given normal daylength. He also discovered that flowering could be delayed by pinching. Pinching the terminal buds on August 25 delayed flowering one week and pinching on September 1 delayed flowering by two weeks.

It has by now become obvious that there are three important factors which influence flower bud initiation of poinsettias, photoperiod, temperature, and light intensity. Much of the most recent work has been to study the effects of one or more of these factors and much of the material discovered is contradictory.

Post (16) states that flower bud initiation occurs in Ithaca, New York around October 10. Many workers have used this date in making recommendations to growers of poinsettias as a reference point for lighting schedules. Post has already suggested that poinsettia flowering can be delayed by applying long days beginning October 10 and continuing for the number of days that delay is desired (16).

Kiplinger (9) in work at Wooster, Ohio (latitude 41° N) determined that floral initiation occurs about September 25. Using this as a basis, he recommends that poinsettias be subjected to an interrupted dark period by applying artificial light each night from 10 PM until midnight beginning September 20 and continuing until October 5. The same equipment which is used for chrysanthemums can be used in this case. Mastalerz (12) suggests that the same materials and schedules can be used to delay flowering of poinsettias in Massachusetts. The only deterrent to this system is that Kiplinger (9) claims that plants which have received long day treatments may be taller and therefore less desirable than plants which have not been given additional illumination.

Sheehan (22) made a number of observations on poinsettia flowering in Florida where the plants will flower outdoors normally in December. At a latitude of approximately 30° N flower bud initiation occurs about October 10. He also pointed out that periods of dark rainy weather that occurred during the latter part of September and early October often caused an early initiation of flower buds and the plants would flower earlier than normal.

A number of growers in California reported that they were having trouble not with early flowering, but with late flowering. Kofranek and Sciaroni (10) set up an experiment where they sampled the tips of poinsettia plants and sectioned them for microscopic observation. The sampling began on September 20 and was repeated every three days until October 30. Work was done at Los Angeles (latitude 34° N) and at San Francisco (latitude 37½° N) on four varieties: Indianapolis Red, Henrieta Ecke, Albert Ecke, and Barbara Ecke Supreme. They found that flower bud initiation occurred on Henrieta Ecke between September 20 and October 4 at both Los Angeles and San Francisco. During this period the photoperiod was about 12 hours and 41 minutes which also included civil twilight. The variety Albert Ecke initiated flower buds between October 4 and 10 at Los Angeles and between October 7 and 13 at San Francisco.

The same year these workers also sampled tips from poinsettia plants growing in commercial greenhouse ranges and took light intensity measurements in an attempt to correlate delayed flowering with low light intensity. The following is a table showing the results of their observations in the greenhouse ranges:

Variety	Location	Average bud initiation date	Relative light intensity
Indianapolis Red	East Palo Alto	Sept. 25 - Sept. 30	High
Indianapolis Red	San Francisco	Sept. 30 - Oct. 5	Medium
Barbara Ecke Sup.	East Palo Alto	Sept. 30 - Oct. 5	High
Barbara Ecke Sup.	Colma	Sept. 30 - Oct. 8	Medium
Barbara Ecke Sup.	Colma	Oct. 5 - Oct. 12	Low

The authors infer that low light intensity delays flowering and suggest that 2,000 to 3,000 foot candles of light during bud initiation are the most favorable. Unfortunately no information was given in regard to temperature because, according to Post (15), this could have had an influence on bud initiation in this case.

More recently Gartner and McIntyre (8) reported the results of an experiment where they varied both the temperature and photoperiod. They propagated plants of six varieties of poinsettias in mid-August and subjected them to several photoperiods all of which began on September 15 and terminated at weekly intervals from October 1 to October 22. Each series of photoperiods was carried at two different night temperatures.

They found that there is a slight difference in varieties in time of maturity. Plants that were grown at a high temperature matured earlier than those grown at low temperatures. They make a number of recommendations on the basis of their results, most important is that plants should be given additional illumination from September 15 to October 8 at a night temperature of 60° F. This brought their plants into full bloom by December 15. If a higher temperature is maintained, the lighting should be continued until October 12. There was very little difference between plants which were not lighted and those grown at 70° F and lighted until October 15. At 60° F the plants not receiving additional light and those lighted until October 8 showed very little difference. Plants which received normal photoperiod were overmature at marketing time and those which received light treatments were immature, although the latter had better keeping quality. Plants which received additional illumination later than October 22 were immature and unsaleable at the time that a wholesaler would market them.

Langhans and Miller (11) reported in 1957 that some commercial poinsettia growers in New York state were having trouble with late flowering although the majority of growers found that their problem was with early flowering. In some cases plants were in full bloom at Thanksgiving. They recommend that in order to avoid early flowering artificial light should be applied from 12 midnight to 1 AM daily from September 20 to as late as October 10. On October 10 the plants should be shaded with black shade cloth at 4:30 PM and removed at 8:00 AM; this is in order to eliminate any late flowering that may result from the application of lights. Shading can be discontinued after October 25. They also discovered that if plants are subjected to additional light in the middle of the night after Thanksgiving or once the inflorescence is fairly well-developed the plants will still flower normally. They further reported that the use of additional illumination did not cause a significant increase in plant height which is not in accord with the work done by Kiplinger (9).

It has been previously mentioned that many commercial growers have lowered the night temperatures in order to delay flowering of poinsettias. Post (17) states that a minimum night temperature of 60° to 62° F is necessary during the flower bud-forming period but after this the temperature may be dropped below 60° F in order to delay the flower development. He adds, however, that there may be some yellowing and abscission of the leaves at these temperatures.

In later work Post, Bing, and Horton (19) report that poinsettias grow little at temperatures below 60° F. They recommend that stock plants, cuttings and young plants should not be grown at temperatures below 70° F, and 80° F is even better. On October 1 the temperatures can be lowered to 60° F for flower bud initiation and development. A study of root growth indicated that roots grew very poorly at a temperature of 60° F as compared to higher temperatures. Root growth is also less when the days are short. Therefore the two factors combined cause an extremely slow rate of root growth. This was felt to be the cause of some of the yellowing and abscission of foliage.

Tomkins and Middleton (23) reported that the wilting, yellowing and abscission of the leaves of poinsettia plants is actually a disease caused by any one or combination of several fungi. The causal organisms, all of which attack the root system of the plant, are *Pythium debaryanum* Hesse., *P. perniciosum* Serbinow, *P. ultimum* Trow, and *Rhizoctonia solani* Kuhn. It is believed that the latter is responsible for over 90% of the infections (9), (23). The environment favoring these organisms is excessive soil moisture, high humidity, overcrowding of plants, and temperatures over 80° F or below 60° F. Since these organisms are most active at temperatures below 60° and poinsettias produce poor root systems at this temperature, it seems only reasonable that infection will be greatest under these conditions.

Kiplinger (9) states that there is a third organism which will cause similar symptoms on poinsettia plants. This is *Thielaviopsis basicolor*. Dimock (6) believes that practically all poinsettia root rot is caused by this organism. Since *Thielaviopsis* requires about the same conditions for optimum growth as do *Pythium* and *Rhizoctonia* the means of preventing infection is about the same. Dimock (6) states the symptoms are expressed only when the plant is not growing actively. When the plant is continuously producing new roots, the attacks by the various fungi are not severe. Thus if a grower's plants are infested by any of these fungi, they may not be apparent until the temperature is lowered, possibly to delay flowering. At such time growth of the plant is reduced while the parasite becomes more aggressive and often causes the death of the entire plant.

With an understanding of the difficulties that arise by reducing temperature, to delay flowering of poinsettias, it seems reasonable to assume that the most practical means of accomplishing this delay is by manipulating the photoperiod.

SUMMARY

Flower buds are initiated on poinsettias when the daylength is about 12 hours (17), they are initiated more rapidly and uniformly when the daylength is 8 to 10 hours (13), (19). In Amherst, Massachusetts the ideal daylength would occur during the last week in September or the first week in October (12). Post (16) contends that in order to delay flowering the days should be lengthened beginning October 10 and continuing for as many days as delay in flowering is desired. Other workers make a number of different recommendations for lighting ranging from dates starting in late August until any time from the first to middle part of October; and still others suggest best results from lighting from mid to late September until early or mid October.

MATERIALS AND METHODS

The plants used in this experiment were all of the variety Barbara Ecke Supreme. They were all obtained from the same source, Aitkens Greenhouses of Agawam, Massachusetts, as rooted cuttings. This variety was selected because it is one of the most widely grown varieties in this area.

Composted soil to which was added 1/5 by volume of peat moss and 1/5 of sand was used as the potting medium. All soil was steam sterilized after mixing and soil tests were made to determine if any nutrient deficiencies existed. Plants were fertilized regularly with a 15-30-15 liquid fertilizer. The rooted cuttings were potted in 3-inch standard clay pots on the same day that they were removed from the cutting bench and were all of fairly uniform size. The dates of potting are as follows: I. July 7 (propagated in June); II. August 6 (propagated in July); III. September 4 (propagated in August).

Each lot of plants was placed under a covering of polyethylene plastic and cheesecloth for five days after potting. This maintained a lower light intensity and higher humidity around the plants and greatly reduced wilting of the young plants thus enabling them to become established more rapidly. When the plants were removed from the shady, humid environment, they were watered and syringed two or three times a day for several days to avoid serious wilting.

On September 30 all plants were placed in 8-inch clay pans, three plants to a pan. They were all panned at the same time to eliminate any differences in plant height which might have occurred had they been panned at different times. Care was taken during the panning operation to keep the original ball of soil at the same height in the pan. This also prevented any additional variation in plant height due to cultural practice.

One pan from each propagation date containing three plants was exposed to seven different photoperiods. Each treatment was replicated 4 times thus giving a total of 12 plants per treatment. This is more than twice as many plants as was used by Gartner and McIntyre (8) who used only 5 plants (replicates) per treatment. The reasons for using this number of plants were: 1. It was believed that the larger number of plants would provide a better sample and therefore more accurate information; 2. Commercially, poinsettias are grown 3 plants to a pan and it was felt that this design might provide better information for commercial recommendations. The pots were placed on a raised greenhouse bench on coarse sand or peastone gravel during the course of the experiment.

In reviewing the literature, it became apparent that two weeks of additional illumination is usually sufficient to delay flower bud initiation of poinsettias. The important question to be decided is at what period to apply this additional light. Photoperiods were chosen that bracketed all of the other photoperiod treatments which had been suggested in the literature as being most effective in influencing the date of flowering and whether these photoperiod treatments would influence the flowering of plants which were propagated in June, July and August.

Plants from each propagation were subjected to two hours of additional light daily from 10 PM to midnight according to the following schedule:

A Control. Received normal daylength throughout growing period.

B Artificial light applied from September 13 to September 27.

C Artificial light applied from September 20 to October 4.

D Artificial light applied from September 27 to October 11.

E Artificial light applied from October 4 to October 18.

F Artificial light applied from October 11 to October 25.

G Artificial light applied from October 18 to November 1.

In this manner plants were exposed to long days for two weeks starting and ending at weekly intervals.

Borthwick, Parker, and Hendricks (4) studied the various types of light that could influence flower bud initiation. They found that the red wave lengths are most effective in inhibiting flower bud initiation. Since 80% of the visible radiation from incandescent filament lamps is in the red region of the spectrum, they are the most practical means of preventing flower initiation and were therefore used in this experiment.

Supplemental light treatments were provided by 75-watt flood type reflector lamps spaced three feet apart and three feet above the plants. Light intensities at the tips of the plants ranged from 25 foot candles near the edges of the group to 50 foot candles directly beneath the lamps. According to the work of Parker, Borthwick, and Rappleye (13) this intensity was assumed to be adequate to prevent flower bud initiation.

Plants receiving photoperiod treatments were placed in a separate greenhouse from those not receiving treatment. The temperatures in both greenhouses were maintained as near 62° F at night as possible. In order to eliminate any error which might arise from a temperature difference or some other environmental factor, six of the control plants were placed in the same greenhouse at the time as were corresponding plants which were to receive the supplemental light. They were removed with the treated plants and data was taken from them to determine if any important increase in stem length had occurred during their stay in the treatment greenhouse. They were protected from receiving any light from the electric lights by black shade cloth hung between them and the source of light. Black shade cloth was also placed near the end of the greenhouse to avoid any external sources of light from reaching the control plants. Light readings were made over the plants periodically but never was there any measurable light noted.

On November 12, all plants were staked and tied. At this time they were rearranged on the greenhouse bench. In order to distribute the treatments on the bench, six cards with the treatment letters B, C, D, E, F, and G were placed in a box, shuffled and drawn out one at a time. The order in which they were drawn determined the sequence that they were placed on the bench. In this manner, all treatments remained separated on the bench thus making it easier to collect the data. Unilluminated control plants were placed in the greenhouse along with the plants receiving illumination and were separated by black shade cloth; therefore, except for additional light, the control plants received the same environmental conditions as the illuminated plants. In this way a direct comparison could be made between the controls and the treatments. Within treatments, each replication from a propagation period was placed at random to eliminate any influence from other factors such as shadows, drafts, or temperature differences which might occur at different parts of greenhouses. Light measurements were taken several times during the day and there were approximately 1500 to 3000 foot candles of light on bright days and 500 to 800 on dark days. During the night there was never any measurable amount of light observed in the greenhouse where the plants were growing. Temperature records were kept by means of a thermograph and the mean night temperature during the growing period was calculated to be 63° F.

Measurements were made on all plants before and after they received the photoperiod treatment as well as the control plants that accompanied them to the separate greenhouse. Other data which was collected periodically are date of first visible appearance of flower buds and date that bracts first showed color. Final data was taken when anthesis occurred. Anthesis was recorded as occurring on the day the first stamens in the inflorescence became erect. Nectar secretion had not always begun at the time of anthesis. At this time the following data was collected: plant height, bract diameter, and number of bracts present.

The height of the plant was measured to the nearest ¼-inch from the surface of the soil next to the stem to the tip of the cyathia. Bract diameter was determined by measuring the diameter across the center of the inflorescence and then another measurement at right angles to the first. The average of the two dimensions was recorded as the diameter of the bract.

A number of plants from each treatment were sampled at random and placed in the homes of faculty members the day before Christmas. These plants were accompanied by a questionnaire to be filled in and returned. From this date it was hoped to obtain an index to the "keeping quality" of these plants under conditions in the home to see if the delayed flowering would improve the keeping quality of the plants.

RESULTS AND DISCUSSION

The results obtained in this experiment are shown in Tables I through V which show the mean date of flowering, growth during photoperiod treatment, height of plants, diameter of inflorescence, and the number of bracts. The optimum date at which poinsettia flowers should become fully open is debatable; however, one week before Christmas most wholesalers prefer plants whose flowers are just beginning to open. In view of this, December 18 was chosen as being the best date to have the plants at the optimum stage of development for Christmas sale.

It can be seen from Table I that plants which are propagated early in the summer normally flower earlier than plants which are propagated later. There could be several reasons for this difference. One could be that there is another factor besides temperature and photoperiod which influences flower bud initiation such as the age of the plant. Another reason for this difference could be that the plants which were propagated later might not have become established as rapidly as those which were propagated earlier, and physiologically were not ready to initiate flower buds. If the latter were the case, it would be expected that vegetative growth would also be retarded slightly until the plants were fully established. This is the case as is seen in Table II. The mean growth of plants propagated during July and August was less than that of the plants propagated in June during the two-week photoperiod. Also from Table II it can be seen that there is more variation between the treated plants than the controls in the June propagation. Therefore, it seems reasonable to assume that the

Table I. Mean Date of Flowering of Plants

	Period of illumination	Propagated		
		I June	II July	III August
A	Control	Dec. 5	Dec. 9	Dec. 14
B	Sept. 13 - Sept. 27	Dec. 11	Dec. 20	Dec. 17
C	Sept. 20 - Oct. 4	Dec. 14	Dec. 19	Dec. 17
D	Sept. 27 - Oct. 18	Dec. 10	Dec. 24	Dec. 20
E	Oct. 4 - Oct. 18	Dec. 15	Dec. 24	Dec. 28
F	Oct. 11 - Oct. 25	Dec. 27	Dec. 30 a	Dec. 30 a
G	Oct. 18 - Nov. 1	Dec. 27	Dec. 24	Dec. 30 a

a. Data was taken on December 30 on each plant that had not flowered at that time.

Table II. Mean Growth (in inches) During Two-week Photoperiod

Period of illumination		Propagated					
		I June	sd	II July	sd	III August	sd
A	Control	2.83	.61	1.33	.32	1.72	.65
B	Sept. 13 - Sept. 27	3.89	1.49	0.83	.31	1.94	.61
C	Sept. 20 - Oct. 4	3.19	1.22	1.21	.33	2.25	.74
D	Sept. 27 - Oct. 11	3.00	1.10	0.58	.13	2.15	.76
E	Oct. 4 - Oct. 18	4.15	1.59	1.69	.63	2.08	.78
F	Oct. 11 - Oct. 25	3.00	1.19	2.38	.82	2.46	.85
G	Oct. 18 - Nov. 1	3.13	1.32	3.19	1.26	2.02	.83

sd - Standard Deviation

age of the poinsettia plant must also be of concern to a commercial grower in any consideration that is given to the factors which cause floral initiation of poinsettia plants.

From Table I it also becomes obvious that the application of two hours of artificial light applied from 10 PM to midnight daily for two-week periods will greatly delay flowering of poinsettias. Also the period at which this photoperiod is applied is directly related to the date of the propagation of the poinsettia plant. Artificial light applied for a two-week period earlier than September 27, to plants propagated in June will not delay flowering of the plants sufficiently to have them at the optimum stage of development for Christmas sale. Conversely, plants propagated in June should not be subjected to artificial illumination later than October 18 or their flowering will be retarded later than a date which will be acceptable to a wholesaler. Plants from this propagation which received an artificial photoperiod later than October 25 did not flower until after Christmas and therefore would have been unacceptable to the market, even though the bracts had good color. A representative plant from each of these treatments is illustrated in Figure I, and the immature bract formation on treatments F and G should be noted.

Plants which were propagated during July and August did not show as much difference in date of flowering between themselves as they did between the plants propagated in June; therefore, they can be handled in much the same way as far as applying additional light to delay flowering. The application of two-weeks of additional illumination after October 11 may cause the plants to flower too late for Christmas sale and those which are subjected to artificial lights after October 18 will not flower until after Christmas. The optimum period for applying additional photoperiod is from September 20 to October 4 for plants propagated at this time. A representative plant from each of the treatments is illustrated in Figure II, and the plants which were propagated in August are illustrated in Figure III.

There is some variation in the mean date of flowering but this is believed due to the normal variation of the individual plants. The greatest amount of variation was in treatment F, plants which received additional photoperiod from October 11 to October 25. Apparently when the different treatments were distributed on the greenhouse bench after they had received the photoperiod treatments, this treatment was not placed in as favorable location as the other groups of plants. The control plants which were placed with this lot of treated plants also flowered slightly later than the control plants which were placed with other treatments. Treatment F received a position at the west end of the greenhouse bench, and while no records are available, it is believed that the temperature at this position was a little lower than at the rest of the greenhouse bench. Post (15) (16) (17) and Post, Bing, and Horton (19) report that a lower temperature retards the maturity of poinsettias and this is believed to be the case with this particular treatment.

The question may be raised as to whether these results could be obtained another year. Sheehan (22) states that periods of dark rainy weather during flower bud initiation cause earlier flowering of poinsettias than

Figure I. Influence of photoperiod on plants propagated in June.

Photograph taken December 22.

B Additional light applied September 13 - September 27.
C Additional light applied September 20 - October 4.
D Additional light applied September 27 - October 11.

E Additional light applied October 4 - October 18.
F Additional light applied October 11 - October 25.
G Additional light applied October 18 - November 1.

Figure II. Influence of photoperiod on plants propagated in July.

Photograph taken December 22.

B Additional light applied September 13 - September 27.
C Additional light applied September 20 - October 4.
D Additional light applied September 27 - October 11.

E Additional light applied October 4 - October 18.
F Additional light applied October 11 - October 25.
G Additional light applied October 18 - November 1.

Figure III. Influence of photoperiod on plants propagated in August.

Photograph taken December 22.

B Additional light applied September 13 - September 27.
C Additional light applied September 20 - October 4.
D Additional light applied September 27 - October 11.

E Additional light applied October 4 - October 18.
F Additional light applied October 11 - October 25.
G Additional light applied October 18 - November 1.

is normal. Therefore, even a slight amount of dark weather more than normal during the flower bud forming period would cause a corresponding earlier date of flowering. Meteorological observations taken by Barton (2) for the Amherst area during September and October, 1957, the two months when any flower bud initiation is assumed to be occurring, show that these months had a greater number of clear days, a fewer number of cloudy days, and a greater number of hours of bright sunshine than occur during a normal year. Therefore, without any artificial photoperiod, it can be assumed that flowering of poinsettias would have occurred slightly later than normal due to the exceptionally bright season during the period of floral initiation. It also appears reasonable that any application of lights during a normal year when the plants would flower earlier would delay the flowering to a date closer to that when the plants would be most acceptable to the wholesaler.

Most of the plants in treatments F and G from the group propagated in August still had not flowered on December 30. Results were taken on all these plants at this time as it was felt that they had provided the information that was desired and since they are a seasonal crop they had no further value commercially.

From Table III it is obvious that plants which are propagated early are taller than those which are propagated later. However, the plants which received additional illumination were not much taller than those plants which received no photoperiod treatment and this difference was felt to be unimportant commercially as total plant height was not objectionable in any of the treatments.

Table III. Mean Height (in inches) of Plants at Time of Anthesis

Period of illumination	Propagated I June	sd	II July	sd	III August	sd
A Control	21.88	6.55	18.32	5.32	14.96	4.85
B Sept. 13 - Sept. 27	22.58	6.81	18.67	5.57	18.06	5.44
C Sept. 20 - Oct. 4	27.06	8.11	22.06	6.65	17.13	5.22
D Sept. 27 - Oct. 11	26.05	8.24	23.00	6.88	17.02	5.26
E Oct. 4 - Oct. 18	28.60	8.02	20.33	7.17	15.25	5.71
F Oct. 11 - Oct. 25	27.08	8.07	24.25	7.24	15.75	4.81
G Oct. 18 - Nov. 1	26.88	8.08	26.61	8.35	15.25	5.10

sd - Standard Deviation

These same observations can also be made in Table II where the rate of growth of the plants during the photoperiod treatments is given. These findings are in accord with Kiplinger (9) who claims that plants which have received long day treatments may be taller. He also indicates that these taller plants may be less desirable because of their increased height. However, from the data obtained in this experiment, it would not appear that the increased height would be of any concern.

As is shown in Table IV, there is no important difference in the bract size of any of the plants. Even the bracts of plants which were propagated in June and had a growing period two months longer than those propagated in August were not larger and in several cases were slightly smaller. It would therefore appear that neither the time of propagation or the application of additional illumination have any effect on the bract size of this variety of poinsettia. This same reasoning would also apply with the number of bracts present in the inflorescence since from Table V it is apparent that there are also no important differences in the number of bracts between any of the light treatments or between the plants from the different propagations.

The information obtained from the faculty members who received the poinsettias for observations in the home cannot be considered statistically valid due to the differences in care and environment that the plants received; however, the information did show a striking difference in the "keeping quality" of the treated plants and the untreated ones. Plants which received no additional photoperiod lost their attractiveness an average of six days earlier than did plants which had received photoperiod treatments. The data obtained did not show any

Table IV. Mean Diameter (in inches) of Inflorescence at Time of Anthesis

Period of illumination	Propagated					
	I June	sd	II July	sd	III August	sd
A Control	11.6	3.50	12.9	3.59	11.3	3.35
B Sept. 13 - Sept. 27	11.8	3.26	11.0	3.23	12.5	3.67
C Sept. 20 - Oct. 4	11.8	3.44	12.0	3.50	11.5	3.37
D Sept. 27 - Oct. 11	10.2	2.89	13.0	3.78	11.2	3.32
E Oct. 4 - Oct. 18	10.6	3.18	10.3	3.50	9.9	3.40
F Oct. 11 - Oct. 25	11.6	3.38	11.0	3.20	8.3	2.46
G Oct. 18 - Nov. 1	13.0	3.81	12.8	4.34	11.0	3.56

sd - Standard Deviation

Table V. Mean Number of Bracts at Time of Anthesis

Period of illumination	Propagated					
	I June	sd	II July	sd	III August	sd
A Control	21.4	3.61	20.8	4.74	18.8	5.69
B Sept. 13 - Sept. 27	20.9	4.45	17.9	3.98	18.3	5.48
C Sept. 20 - Oct. 4	21.8	6.53	19.8	5.88	18.6	5.68
D Sept. 27 - Oct. 11	24.8	7.12	20.6	6.13	15.1	4.99
E Oct. 4 - Oct. 18	26.1	7.99	17.3	6.14	18.3	6.53
F Oct. 11 - Oct. 25	22.8	6.99	24.8	7.56	13.8	4.17
G Oct. 18 - Nov. 1	21.3	6.43	21.3	7.57	20.1	6.81

sd - Standard Deviation.

great differences or trends in the "keeping quality" among plants which received different photoperiod treatments.

A very interesting observation was made on plants from all the propagation periods which received additional illumination after October 4. This was the presence of an abnormal type of inflorescence. The normal poinsettia inflorescence is a cluster of flowers or cyathia surrounded by a whorl of colored bracts as illustrated in Figure V. Inflorescences on all the control plants and all plants in treatments B and C were normal.

The abnormal type of inflorescence which occurred on all plants in treatments D, E, F, and G was actually a cluster of three separate inflorescences. On close examination, it was found that the main axis of the plant was terminated by a single cyathium. At the point of origin on the stem where this cyathium arose, the stem had branched three times, and each of these branches was a peduncle ranging in length from $\frac{3}{4}$ inches to 2 inches which supported a complete inflorescence. This abnormal inflorescence is illustrated in Figure IV. It should be noted that the innermost bracts of each inflorescence have been turned back in order to expose the single cyathium at the point where branching occurs.

The answer to this phenomena would appear to be that the poinsettias had begun to initiate flower buds during the latter part of September or early October. The plants were then placed under the photoperiod treatments which are not favorable for flower bud initiation. This floral initiation then became arrested and the plant began to produce vegetative cells again. However, the duration under the photoperiod was not sufficient to allow the plant to produce very many vegetative cells and when

Figure IV. Abnormal inflorescence which occurred on all plants which were lighted after October 4. Picture taken December 22.

Figure V. Normal inflorescence of Euphorbia pulcherrima. This is a control plant which received no additional illumination. Picture taken December 22.

the plant again received short periods of daylength, flower buds were initiated again. The only reference to this in the literature was reported by Beck (3) who used photoperiod to induce branching of poinsettias, but made no mention of any abnormal flower formation.

SUMMARY

Under the conditions of this experiment, the following observations are made.

1. Poinsettia plants which are propagated in June flower earlier than plants which are propagated in July or August.

2. The application of two hours of additional illumination daily from 10 PM to midnight for two-week periods is sufficient to delay flowering.

3. Poinsettia plants which are propagated in June should not receive any additional illumination after October 18. Plants which receive additional photoperiods after this date will mature too late for Christmas.

4. Plants which are propagated during July and August should not receive any additional photoperiods after October 4. Plants which receive additional light after this date may mature too late for Christmas sale.

5. There was a difference in the height of the plants which received two weeks of additional illumination and the height of the control plants; however, this difference was felt to be unimportant.

6. There was no important difference in the diameter of the bracts or in the number of bracts between the control plants and those which received two weeks of additional illumination.

7. All plants which received additional illumination after October 4 produced an abnormal inflorescence which appeared to be a branching of the main stem into three separate peduncles to form 3 distinct inflorescences.

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Approved by:

Robert B. Livingston

Robert B. Livingston

Alfred W. Boicourt

Alfred W. Boicourt

Harold E. White

Harold E. White--Chairman

THESIS COMMITTEE

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